Risk Based Corrective Actions for Petroleum Contaminated Sites

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Saskatchewan Environment
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Risk Based Corrective Actions For Petroleum Contaminated Sites

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RISK BASED CORRECTIVE ACTIONS FOR PETROLEUM CONTAMINATED SITES

1.0 INTRODUCTION

Experience gained both within the province and in other jurisdictions has revealed the need for alternative approaches to the remediation or management of petroleum contaminated sites. More specifically, the development of a Canada-wide Standard for Petroleum Hydrocarbons (PHC) in soil by the Canadian Council of the Ministers of the Environment (CCME) has made it necessary for Saskatchewan Environment to revise the previous Risk Based Corrective Actions at Petroleum Contaminated Sites to reflect this new Canada-wide Standard.

The responsibility for the remediation or management of contamination at a property fundamentally lies with the person(s) causing the contamination. This responsibility stems from *The Environmental Management and Protection Act*. These guidelines are necessary since there is no legislative enactment, by statute or by regulation, prescribing "acceptable" levels of contamination for the purpose of decommissioning a petroleum contaminated facility. As well, specific remedial methodology in legislation for possible contamination scenarios is not practical.

Eventhough, as stated above there are no regulations which prescribe acceptable remediation levels, *The Hazardous Substances and Waste Dangerous Goods Regulations* govern the requirements for the decommissioning of petroleum storage facilities including the removal of the tanks, lines and associated equipment and the decontamination and reclamation or monitoring and management of all affected areas. Section 17 of the regulations state:

17(1) No person shall remove, abandon, dispose or permanently close all or part of any storage facility without the prior approval of the minister to decommission the storage facility and decontaminate and reclaim or manage and monitor every affected area.

17(2) At least 30 days prior to the removal, abandonment, disposal or permanent closure of a storage facility, the owner or operator of the storage facility shall submit a decommissioning application to the minister containing:

(a) A description of how the decommissioning is to take place;
(b) A description of the plans for the disposal of any remaining equipment, hazardous substances, waste dangerous goods or contaminated materials; and
(c) A detailed proposal to:
(i) decontaminate and reclaim the affected area;
(ii) to monitor and manage the affected area; or
(iii) that consists of a combination of decontaminating and reclaiming and monitoring and managing pursuant to subclauses (i) and (ii).

17(3) Before making a proposal pursuant to subclause (2)(c)(ii), the owner or operator shall carry out a site assessment to determine the degree of contamination, the risks to the environment and the risks to the health and safety of the public.

17(4) Within 12 months of the date of approval, an owner or operator of a storage facility, in accordance with the terms of the approval, shall decommission the facility and:

(a) decontaminate and reclaim the affected area; or
(b) Initiate monitoring and management of the contamination and associated risks.

17(5) Not withstanding any other provision in these regulations, no owner or operator of an underground storage tank shall abandon or permanently close the underground storage tank unless the underground storage tanks is:

(a) emptied;
(b) removed from the ground; and
(c) rendered unfit for further use for the storage of hazardous substances or waste dangerous goods.

17(6) No person to whom an approval is issued pursuant to this section shall fail to comply with the terms of the approval.

17(7) No person shall decommission, remove, abandon dispose or permanently close an underground tank used for the storage of petroleum products other than by the means of the services of a qualified person or under the supervision of a person designated by the minister.

17(8) No person shall decommission, remove, abandon, dispose or permanently close an underground tank used for the storage of waste dangerous goods other than under the supervision of a person designated by the minister.

Therefore, Saskatchewan Environment, in administering the above Act and Regulations, has developed and revised these Risk Based Corrective Actions for Petroleum Contaminated Sites to reflect and adopt the Canada-wide Standard for Petroleum Hydrocarbons and to update any remediation requirements. These guidelines maintain the previous land use based approach as an option for the decommissioning and remediation of petroleum storage facilities. These revised guidelines also provide options, which parallel the risk based approach developed by CCME - Canada-wide Standards for Petroleum Hydrocarbons in soil.

1.1 Objectives and Scope

PHCs in the environment are a concern for the following reasons:

- The reduced nature and volatility of PHCs pose a fire/explosion hazard.
- Most PHC constituents are toxic to some degree.
- Lighter hydrocarbons are mobile and can be a problem at considerable distances from their point of release due to transport in groundwater or air.
- Larger and branched chain hydrocarbons are persistent in the environment.
- PHCs may create aesthetic problems such as offensive odour, taste or appearance in environmental media.
- Under some conditions PHCs can degrade soil quality by interfering with water retention and transmission, and with nutrient supplies.

Therefore, the objective of these guidelines is to define methods and requirements to be employed for the uniform evaluation, decommissioning and management of PHC contaminated sites within Saskatchewan. These guidelines establish a process whereby parties managing a project and undertake work to ensure risks to human health, safety of the public and the environment are minimized. The guidelines are also intended to assist owners of petroleum storage facilities and persons undertaking management of sites in understanding the requirements of the department when a leak or spill from a storage tank is known or suspected to have occurred.

These guidelines may be applied to active, closed or abandoned sites having underground or aboveground tanks used for the storage of petroleum products, specifically but not limited to the following substances; Gasoline, Diesel, Heating Oil, Aviation Fuel, Waste Oil.

2.0 REPORTING, DECOMMISSIONING, AND CLOSURE

Outlined in the following section are the available options and steps to be taken by operators, owners and persons performing the required remediation and/or assessment. The reporting,

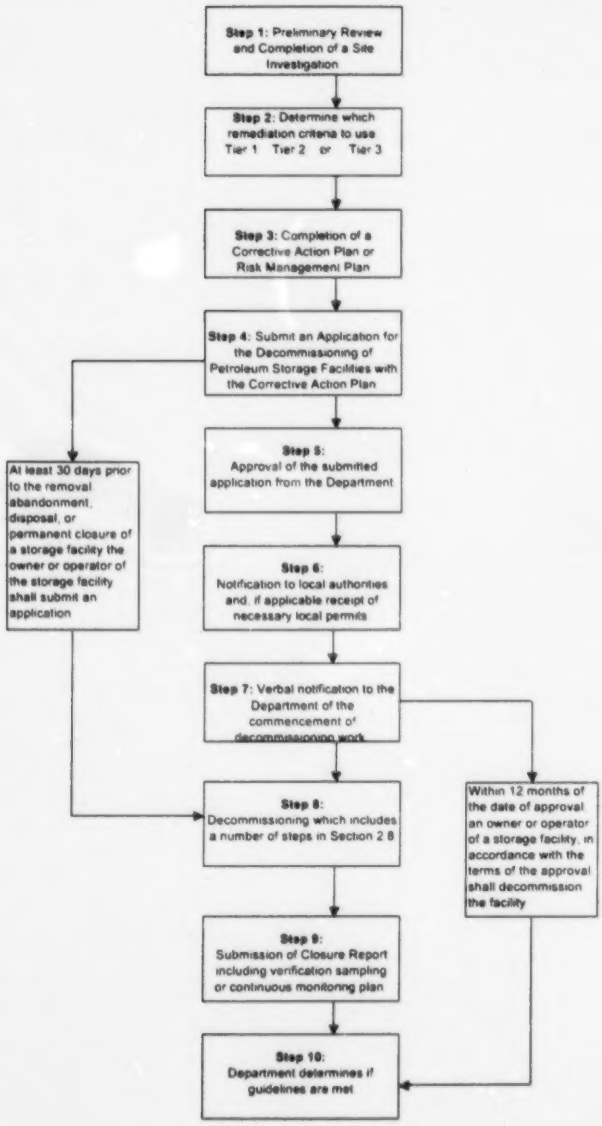

Step 1: Preliminary Review and Completion of a Site Investigation
Step 2: Determine which remediation criteria to use Tier 1 Tier 2 or Tier 3
Step 3: Completion of a Corrective Action Plan or Risk Management Plan
Step 4: Submit an Application for the Decommissioning of Petroleum Storage Facilities with the Corrective Action Plan
At least 30 days prior to the removal abandonment, disposal, or permanent closure of a storage facility the owner or operator of the storage facility shall submit an application
Step 5: Approval of the submitted application from the Department
Step 6: Notification to local authorities and, if applicable receipt of necessary local permits
Step 7: Verbal notification to the Department of the commencement of decommissioning work
Step 8: Decommissioning which includes a number of steps in Section 2.8
Within 12 months of the date of approval an owner or operator of a storage facility, in accordance with the terms of the approval shall decommission the facility
Step 9: Submission of Closure Report including verification sampling or continuous monitoring plan
Step 10: Department determines if guidelines are met

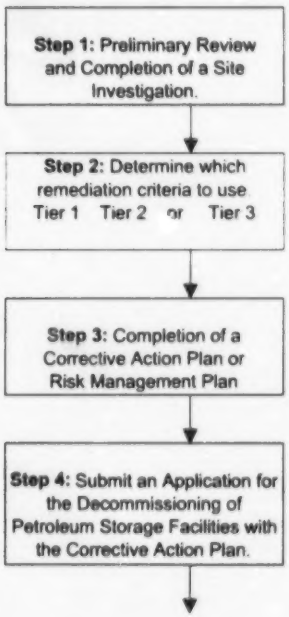
Figure 2.1: Flow chart illustrating the steps required to decommission a petroleum contaminated site.

decommissioning and closure steps and options are discussed in detail. The remediation process generally begins with the decision to take corrective actions. Issues such as groundwater contamination, potential off-site migration of product, contamination of utility trenches and conduits as well as other underground structures, vapour migration, reduced property values, and the results of environmental audits or assessments are all reasons for properly managing risks during the decommissioning of a facility.

The proper decommissioning of above ground and underground storage petroleum tanks includes a number of steps with regards to approval, reporting to the department, decommissioning and closure. First, a preliminary review and the completion of a site investigation is required to formulate a corrective action plan. Once the corrective action plan is completed the proponent may apply to the department for

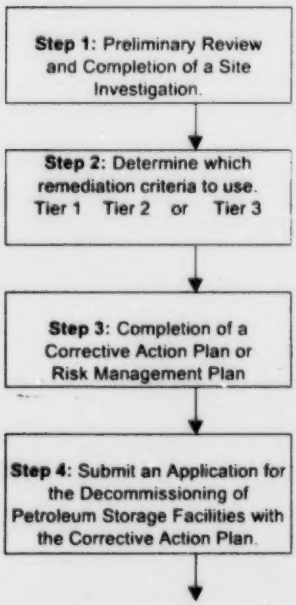
decommissioning. This application must be submitted at least 30 days prior to any decommissioning. As well, during this time, notification may be required by some municipalities which have established bylaws with specific requirements for removal and decommissioning of storage tanks to reduce fire risks and protect publicly owned utilities and infrastructures. Once, the decommissioning approvals have been granted the decommissioning may commence and must be finalized within 12 months. This finalization requires a closure report and requires verification sampling. These steps are illustrated in Figure 2.1 and discussed in depth in the following sections.

2.1 Step 1 - Preliminary Review and Site Investigation


Step 1: Preliminary Review and Completion of a Site Investigation.
Step 2: Determine which remediation criteria to use Tier 1 Tier 2 or Tier 3
Step 3: Completion of a Corrective Action Plan or Risk Management Plan
Step 4: Submit an Application for the Decommissioning of Petroleum Storage Facilities with the Corrective Action Plan.

Decommissioning begins with a preliminary information review and site investigation which will provide the information necessary for the development of a corrective action plan and assist in the proper planning, identification and cleanup of petroleum contamination. In the case of fuel storage facilities, the evaluation will determine the extent of contamination (if any) by identifying the location(s) and degree(s) of petroleum contamination both on and off site. In most cases site investigations are divided into three phases. A Phase 1 site investigation is a preliminary investigation conducted to reveal any potential significant environmental concerns. Phase 2 is a detailed site investigation to confirm and quantify the contamination as indicated in Phase 1. Phase 3 is a more detailed investigation of site conditions. These three phases are described in Appendix 'A'. As well, there are standard documents which describe these phases. Canada

Standards Association document Z768-01 and International Standards Organization 14010-96 give general guidelines for these investigations. Generally, Tier 1 criteria will require a site investigation to at least Phase 2 before the tank removal and excavation component of the project begins. In some small scale situations, parts of the Phase 2 characterization of the extent and degree of contamination may be performed during the actual removal of tanks and contaminated soil. If this is intended, it should be noted in the Corrective Action Plan for the site and areas being addressed. The site investigation methodology and level of detail may vary between sites and in some cases, part of the information may be known beforehand. However, the objective is to outline and, in more involved situations or larger projects, identify the extent of subsurface contamination in order to select the appropriate decommissioning and remediation approach. The site investigation may be quite simple or complex depending on the level of contamination. For further detail refer to Appendix 'A'.


Step 1: Preliminary Review and Completion of a Site Investigation.
Step 2: Determine which remediation criteria to use. Tier 1 Tier 2 or Tier 3
Step 3: Completion of a Corrective Action Plan or Risk Management Plan
Step 4: Submit an Application for the Decommissioning of Petroleum Storage Facilities with the Corrective Action Plan.

2.2 Step 2 - Risk Management Options

Following the completion of a site investigation there are three main decommissioning risk management options that can be taken to address contamination at a site:

Tier 1 – Remediation Based on Future Land Use Criteria;

Tier 2 – Remediation Based on Site Specific Sensitivity;

Tier 3 – Site Specific Risk Assessment and Management.

In the "Tier 1 - Future Land Use Based" remediation option, numerical criteria are provided for remediation of surface and subsurface soil based on future use of the site. A second approach is provided for determining remediation levels based on "Tier 2 - Site Specific Sensitivity" where the

conditions at each site are examined and weighed against scientifically derived models to determine risk and appropriate cleanup levels. Lastly, the owner may decide to undertake a site assessment to develop site and/or parameter specific criteria based on the characteristics and exposure pathways at the location. This last approach, Tier 3, may result in the development of a risk management/monitoring plan where not all contaminants are removed, but the risks are managed and monitored. The regulations also allow combinations of the previously mentioned approaches to be used as the situation or risks demand. Approval from the department is required before pursuing any of these options. These three tiers are explained in more detail in the following sections. As well, there are a number of definitions required to understand the terms used in these three tiers. Therefore, these definitions are supplied in the following section.

2.2.1 Definition of Terms

Definition of PHC

The definition of Petroleum Hydrocarbons (PHC) describes a mixture of organic compounds found in or derived from geological substances such as oil, bitumen and coal. Petroleum products released to the environment, such as petroleum, crude oil and jet fuel, typically contain thousands of compounds in varying proportions, composed predominantly of carbon and hydrogen, with minor amounts of nitrogen, sulphur and oxygen. PHC contamination in soils varies with the petroleum source, soil type, the composition, degree of processing (crude, blended or refined) and the extent of weathering caused by exposure to the environment. Such factors have complicated the assessment of the human and environmental health risks associated with PHC contamination in soils. This complicated assessment of risk made it necessary to evaluate PHC as four fractions; F1, F2, F3 and F4. This is different from previous guidelines where PHC contamination in soil was assessed by one parameter - total petroleum hydrocarbons (TPH). Therefore, CCME has developed a standard method to determine the four fractions - "Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil - Tier 1 Method." These fractions are described below.

PHC fractions

For the purposes of this document, petroleum hydrocarbons are subdivided according to specified ranges of equivalent carbon number (ECN). Each fraction is, in turn, made of subfractions. The subfractions have been described according to their relevant physical and chemical properties and toxicological characteristics. The divisions between the fractions have been established in consideration of analytical factors, physical and chemical properties, the expected relevance to biological response in soils and the ability to utilize the definitions and associated properties.

Fraction 1 encompasses the range of ECN from C6 to C10. It represents the volatile fraction of most hydrocarbon mixtures and consists of aromatic subfractions in the ranges C>7 to C8 and C>8 to C10, as well as aliphatic subfractions in the ranges of C>6 to C8 and C>8 to C10. Specific aromatic compounds falling within this fraction (i.e. BTEX) are normally managed separately and would therefore be subtracted from the aromatics in this fraction.

Fraction 2 encompasses the range of ECN from C>10 to C16. It represents the semi-volatile fraction and comprises aromatics and aliphatic subfractions in the ranges C>10 to C12 and C>12 to C16.

Fraction 3 encompasses the range of ECN from C>16 to C34. It includes both aromatics and aliphatics in the C>16 to C21 and C>21 to C24 ranges.

Fraction 4 encompasses the range of ECN from C>34 to C50. PHC within this range often make up a significant proportion of crude oils and petroleum products, although the fraction is generally considered to be of low mobility, volatility and solubility.

BTEX are those parameters benzene, toluene, ethyl-benzene, xylene.

Land Use Definitions

The PHC CWS in soils has been developed for four generic land uses - agriculture, residential/parkland, commercial and industrial. A generic land use scenario has been envisioned for each category based on the normal activities on these lands. The risk-based nature of these guidelines means that, for each land use, all values to be protected (life-forms or receptors, ecosystem properties) are explicitly documented as well as the contaminants considered within PHC and the pathways by which PHC can affect these values. This approach provides great flexibility, it allows assessment and management of different variations within a land use and even extension of the standard to other land use categories (e.g., wildlands). The four land uses are

defined as follows:

Agricultural lands: where the primary land use is growing crops or tending livestock. This also includes agricultural lands that provide habitat for resident and transitory wildlife and native flora. The portion of a farm that houses people is considered a residential land use.	***Commercial***: where the primary activity is commercial (e.g., shopping mall) and there is free access to all members of the public, including children. The use may include, for example, commercial day-care centres. It does not include operations where food is grown.
Residential/Parkland: where the primary activity is residential or recreational activity. The ecologically-based approach assumes parkland is used as a buffer between areas of residency, but this does not include wild lands such as national or provincial parks, other than campground areas.	***Industrial***: where the primary activity involves the production, manufacture or construction of goods. Public access is restricted and children are not permitted continuous access or occupancy.

Soil Texture Definition

Tier 1 and Tier 2 numerical values are prescribed for coarse-grained and fine-grained soils. Therefore, sufficient textural information should be obtained to permit classification of the soils as either coarse or fine. These are defined as follows:

Fine-grained soil means fine-textured soil having a median grain size of <75um as defined by the American Society for Testing and Materials.	**Coarse-grained soil** means fine-textured soil having a median grain size of >75um as defined by the American Society for Testing and Materials.

Furthermore, the clean-up criteria is different for surface soils than for subsoils. Therefore, for the purpose of this document **subsoil** is that soil which is 1.5 metres or deeper from the surface.

2.2.1 Tier 1 - Remediation Based on Future Land-Use Criteria

The Tier 1 objectives consider four generic land use categories: agricultural, residential/parkland, commercial, and industrial. The land use category must be determined to ensure that the appropriate Tier 1 objectives are applied at the site. Selection of the land use category must consider not only the present use of the site but also potential future use. As well, if no Tier 1 exceedances, according to Tables 2.2.1 and 2.2.2 are found at the site and PHC contamination is at least 30 cm from the foundation of any building and 10 m from any

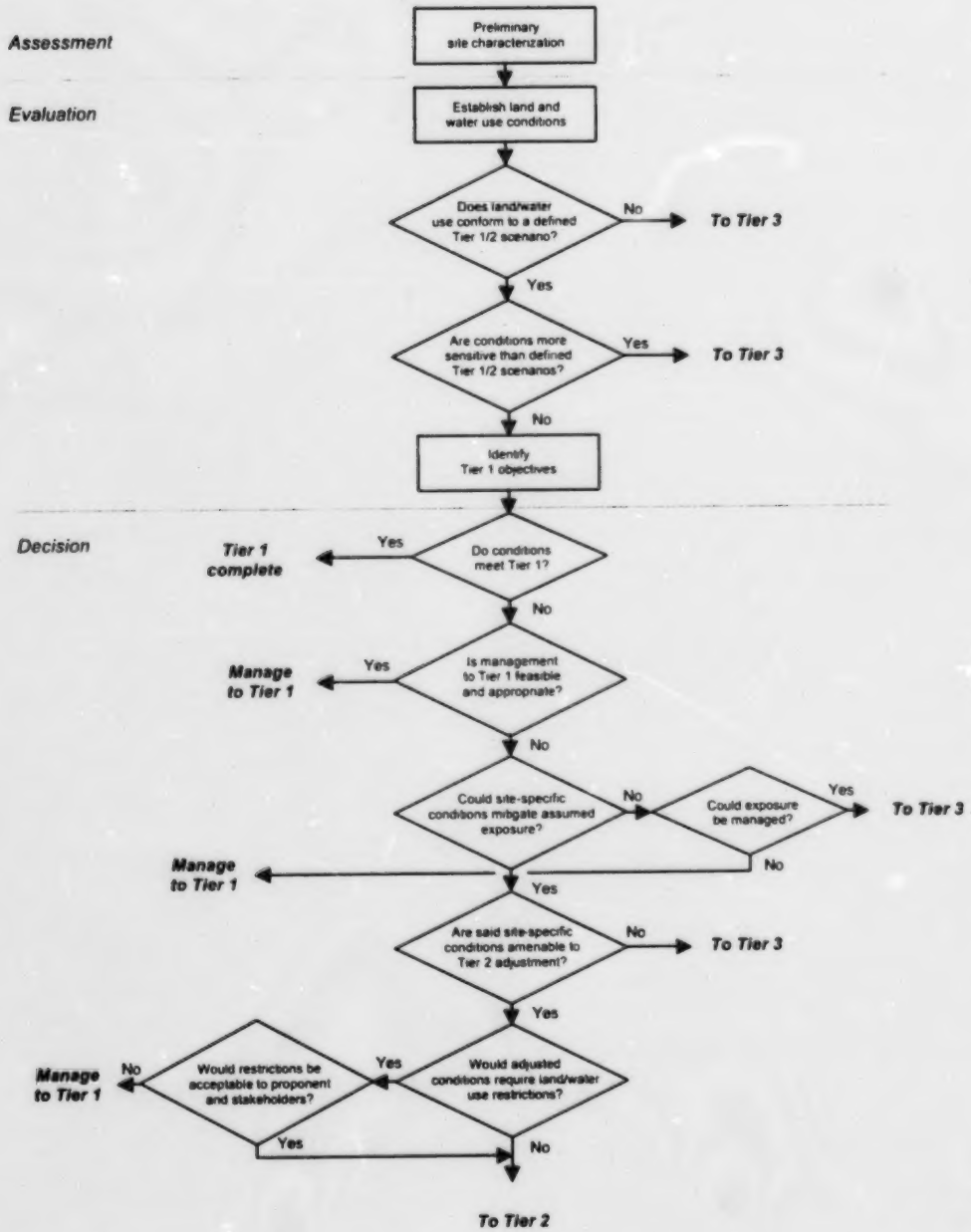


Figure 2.2: Flow diagram – Tiered System

nearby surface water body, the site can be considered to be in compliance with Tier 1 and no further action is necessary. However, if the contamination is within 30 cm of a building or 10 metres of a surface water body the proponent must proceed to Tier 2 or Tier 3. This is illustrated in Figure 2.2.

If exceedences are found, the proponent enters in to a decision process whereby the option of managing to Tier 1 is weighed against the option of proceeding to Tier 2 or Tier 3. Deciding if Tier 1 is appropriate the first consideration is the practical and economic feasibility of management to Tier 1. If this is appropriate the proponent begins to assess and evaluate the conditions to aid in making decisions on appropriate actions. First, the proponent must establish land and water use conditions at the site, thereby, establishing a land use category. In addition the proponent must determine if the conditions conform to a Tier 1 level and from there identify the Tier 1 objectives from Table 2.2.1 and 2.2.2. Otherwise the proponent must proceed to Tier 2 or 3. This stage is illustrated in the Evaluation Section of Figure 2.2.

Table 2.2.1. Summary of Tier 1 Levels (mg/kg) for surface and subsoil fractions.

Land Use	Soil Texture	Surface Fraction F1	Surface Fraction F2	Surface Fraction F3	Surface Fraction F4	Subsoil Fraction F1	Subsoil Fraction F2	Subsoil Fraction F3	Subsoil Fraction F4
Agricultural	Coarse-grained soil	130	450 (150 a)	400	2800	200	1100 (150 a)	2500	10000
	Fine-grained soil	260 (180 b)	900 (250 b)	800	5600	750 (180 b)	2200 (250 b)	3500	10000
Residential/ Parkland	Coarse-grained soil	30 c	150 c	400	2800	40 c	190 c (150 a)	2500	10000
	Fine-grained soil	260 (180 b)	900 (250 b)	800	5600	750 (180 b)	2200 (250 b)	3500	10000
Commercial	Coarse-grained soil	310 (230 a)	760 (150 a)	1700	3300	340 (230 a)	1800 (1200 b) (150 a)	3500	10000
	Fine-grained soil	660 (180 b)	1500 (250 b)	2500	6600	1000 (180 b)	3000 (250 b)	5000	10000
Industrial	Coarse-grained soil	310 (230 a)	760 (150 a)	1700	3300	340 (230 a)	1800 (1200 b) (150 a)	3500	10000
	Fine-grained soil	660 (180 b)	1500 (250 b)	2500	6600	1000 (180 b)	3000 (250 b)	5000	10000

a= Where applicable, for protection against contaminated groundwater discharge to an adjacent surface water body. Assumes surface water body at 10 metres from site.
b= Where applicable, for protection of potable groundwater. Assumes site is underlain by groundwater of potable quality in sufficient yield (K of 10^{-4} cm/sec or greater).
c= assumes contamination near residence with slab-on-grade construction.

Table 2.2.2. Summary of Tier 1 Levels (mg/kg) for surface and subsoil BTEX

(Based on Alberta Environment's "Draft - Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities Volume 3: User Guide (September 2001) ")

Land Use	Soil Texture	Surface Benzene	Surface Toluene	Surface Ethyl-benzene	Surface Xylenes	Subsoil Benzene	Subsoil Toluene	Subsoil Ethyl-benzene	Subsoil Xylenes
Agricultural	Coarse-grained soil	8.3 (1.6 a) (0.13 b) (0.048 c)	24 (1.6 b) (0.16 a)	91 (79 a) (54 c) (0.36 b)	90 (59 a) (49 b) (14 c)	17 (1.6 a) (0.13 b) (0.054 c)	48 (1.6 b) (0.16 a)	180 (79 a) (61 c) (0.36 b)	180 (59 a) (49 b) (15 c)
	Fine-grained soil	14 (1.9 c) (0.073 b)	300 (0.86 b)	450 (0.19 b)	500 (25 b)	28 (1.9 c) (0.073 b)	300 (0.86 b)	450 (0.19 b)	500 (25 b)
Residential/ Parkland	Coarse-grained soil	0.048 c	24 (1.6 b) (0.16 a)	54 c (0.36 b)	14 c	0.054 c	48 (1.6 b) (0.16 a)	61 c (0.36 b)	15 c
	Fine-grained soil	14 (1.9 c) (0.073 b)	300 (0.86 b)	450 (0.19 b)	500 (25 b)	1.9 (0.073 b)	300 (0.86 b)	450 (0.19 b)	500 (25 b)
Commercial	Coarse-grained soil	13 (1.6 a) (0.13 b) (0.55 c)	71 (1.6 b) (0.16 a)	200 (79 a) (0.36 b)	130 (59 a) (49 b)	25 (0.58 c) (1.6 a) (0.13 b)	140 (1.6 b) (0.16 a)	390 (79 a) (0.36 b)	260 (170 c) (59 a) (49 b)
	Fine-grained soil	38 (9 c) (0.073 b)	450 (0.86 b)	690 (0.19 b)	1500 (25 b)	77 (9 c) (0.073 b)	450 (0.86 b)	690 (0.19 b)	1500 (25 b)
Industrial	Coarse-grained soil	13 (1.6 a) (0.13 b) (0.55 c)	71 (1.6 b) (0.16a)	200 (79 a) (0.36 b)	130 (59 a) (49 b)	25 (0.58 c) (1.6 a) (0.13 b)	140 (1.6 b) (0.16 a)	390 (79 a) (0.36 b)	260 (170 c) (59 a) (49 b)
	Fine-grained soil	38 (9 c) (0.073 b)	450 (0.86 b)	690 (0.19 b)	1500 (25 b)	77 (9 c) (0.073 b)	450 (0.86 b)	690 (0.19 b)	1500 (25 b)

a= Where applicable, for protection against contaminated groundwater discharge to an adjacent surface water body. Assumes surface water body within 300 metres from site.
b= Where applicable, for protection of potable groundwater. Assumes site is underlain by groundwater of potable quality in sufficient yield (K of 10^{-4} cm/sec or greater).
c= assumes contamination near residence or building with slab-on-grade construction.

Next, the proponent enters the decision making stage of the process in which it is determined if the conditions meet Tier 1 or can be managed to Tier 1 or site conditions makes it possible to mitigate to Tier 1. If this cannot be determined or achieved the proponent must move to Tier 2 or Tier 3 as illustrated in the Decision Section of Figure 2.2.

2.2.3 Tier 2 - Remediation Based on Site Specific Sensitivity

If the default assumptions, illustrated in the above tables, used in the derivation of the Tier 1 values are conservative relative to actual site-specific conditions, the replacement of default

assumptions with site-specific data for certain influential parameters and/or the elimination of insignificant pathways may permit the development and implementation of less stringent remediation objectives without compromising health and environmental protection goals. Therefore, there are two main approaches to obtain Tier 2 remediation. They are:

1. Generation of generic objectives after eliminating insignificant pathways.
2. Generation of site specific objectives after adjusting site specific parameters.

These two approaches are described below.

Generation of generic objectives after pathway elimination.

Site-specific adjustment of Tier 1 levels based on the absence or elimination of exposure pathways and/or receptors may be permitted at Tier 2 under certain circumstances. The principal consideration is whether the relevant site-specific conditions are fixed or stable and can be predicted or controlled in a generic way. In many cases, site management is required to support elimination of exposure pathways or receptors within a given generic land use, which would necessitate conditions being imposed with respect to site closure. The elimination of exposure pathways may be permitted under the following circumstances:

Offsite migration pathway
The elimination of this pathway would generally be permitted for industrial land use. The purpose of this pathway is to protect adjacent, more sensitive, land from the deposition of PHC contaminated soil and dust originating from the erosion of industrial land. If surrounding land use is similar, this pathway may be eliminated from consideration.

The protection of groundwater for aquatic life pathway
May be eliminated if the contamination is not within 10 metres from a surface water body. This is only appropriate for F1, F2, F3 and F4 fractions. However, this pathway may be eliminated for BTEX where there are no surface water bodies within 300 metres downgradient of the site. Downgradient is defined as any direction within 45 degrees either side of the direction of groundwater flow. This pathway may only be eliminated for small release sites such as fuel stations and cannot be applied to large release sites such as refineries.

Ecological soil contact pathway
Elimination that may be allowed is the exclusion of the ecological soil contact pathway from consideration on industrial or commercial land where the site is completely paved, graveled or capped, and where no productive use of the soil system is anticipated or required.

Potable groundwater pathway
The potable groundwater pathway may be eliminated if it is determined either qualitatively or quantatively that there is a horizontal hydraulic conductivity of less than 10^{-4} cm/sec. This value is the conductivity to support consumptive use for a small family.

Vapour inhalation pathway
This pathway may be eliminated if the buildings on the property are removed or demolished.

It is interesting to note, generation of site specific objectives will only be effective if the ecological soil contact pathway is eliminated. The soil contact pathway may not be excluded for agricultural or residential land use. Therefore, Tier 2 is not an option when the ecological pathway governs or the land use is deemed to be agricultural or residential. However, the proponent may use Tier 2 objectives and eliminate pathways depending on the site and soil conditions to determine the minimum clean up objectives if the site is deemed commercial or industrial and the soil contact pathway may be eliminated. The different pathway eliminations with objectives for Tier 2 are illustrated in Figure 2.3. As well, in these scenarios it is evident that testing for fractions F3 and F4 are not required. The proponent must examine the Tier 1 or Tier 3 approaches for site remediation if the soil contact pathway can not be eliminated. In Appendix 'B' there are tables which display all the generic objectives with respect to all pathways.

Generation of site specific objectives after adjusting site specific parameters.

In the event that certain pathways, such as the protection of groundwater for aquatic life, or protection of potable groundwater or vapour inhalation (indoor) pathways may not be eliminated there are other mechanisms in place to generate site specific objectives. The adjustment procedures for these pathways may be obtained from Appendix 'D' of the user guidance of the *Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil.*

As well, a qualified consultant may carry out the calculations using those procedures described in the user guidance at the CCME website www.ccme.ca. Furthermore, point-of-exposure measurements, if lower than those predicted using the relatively conservative modeling procedures employed at Tier 1, may also permit the implementation of less stringent objectives. This procedure is also described in the Total Petroleum Hydrocarbon Canada-wide Standard.

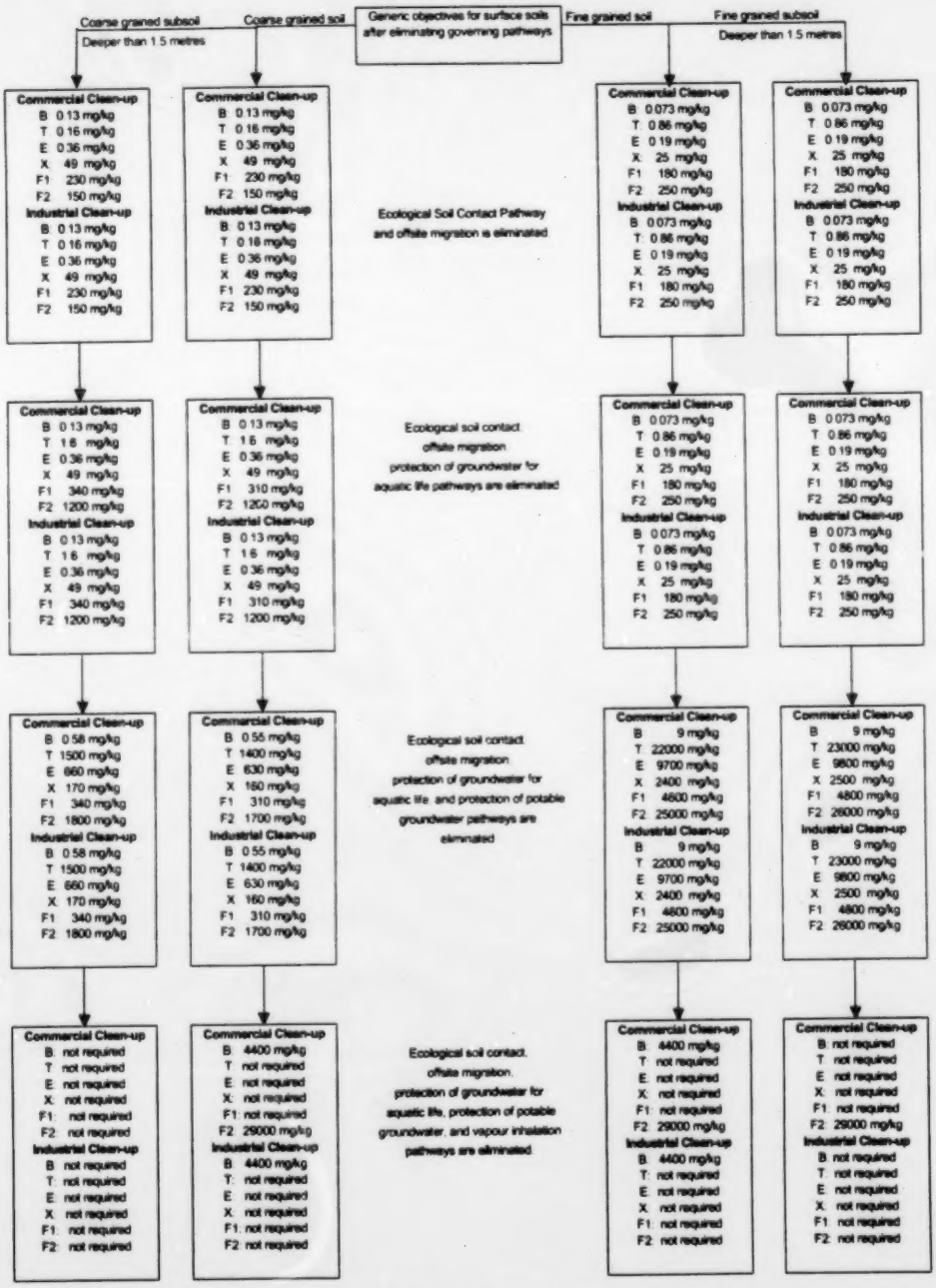


Figure 2.3: Generic objectives for Tier 2 after the elimination of insignificant pathways.

2.2.4 Tier 3 - Site-specific Risk Assessment and Management

Since the options for including site-specific information at Tier 2 are limited, the parameters and assumptions may be such that the Tier 2 exposure scenario is still conservative relative to site-specific conditions. Additional site-specific factors may exist that would mitigate exposure, leading to the development of less stringent remediation objectives. If so, these factors may be incorporated at Tier 3. Examples of site-specific conditions that may mitigate exposure, which could be incorporated at Tier 3, include:

1. Site-specific, manageable human receptor characteristics, such as frequency of exposure.
2. Present building location and configuration.
3. Restrictions on human access.
4. Nature and location of existing water use and opportunity to manage future use.

Alternatively, exposure could be mitigated through the implementation of management measures designed to control exposure or off-site migration, such as elimination of exposure pathways by means of engineered controls (e.g. physical barriers, hydraulic controls). If site-specific factors are not assessed as having the potential for mitigating exposure, or if exposures could not otherwise be managed, Tier 3 would not be considered viable and the proponent will return to Tier 2.

If, however, there is an opportunity for relief at Tier 3, the proponent must assess the costs and benefits and the impact of restrictions prior to making the decision to proceed to Tier 3. Detailed site-specific human health and ecological risk assessments are considerably more intensive with respect to investigation, data requirements, computation and modelling, and regulatory review, than Tier 2 adjustments or screening level risk assessments. For example, site-specific ecological risk assessments for PHC are likely to require the establishment of toxicity data specific to the receptors, soil type and PHC composition. In general, site-specific risk assessment is a powerful and flexible tool for the purpose of developing appropriate and cost-effective risk management strategies for PHC contaminated sites. However, the proponent should beware of the requirements of the approach before committing to Tier 3 management.

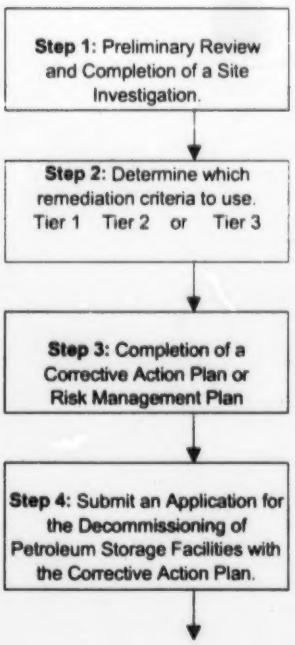
If the benefits of site-specific risk assessment and risk management do not outweigh the

restrictions, costs and regulatory burden, the proponent will return to Tier 2. If Tier 3 is considered advantageous, the acceptability of the associated restrictions and conditions must be assessed, at least at a preliminary level, before proceeding to the implementation of Tier 3.

Tier 3 involves the completion of a site-specific risk assessment and the development of a risk management plan. Detailed guidance on human health and ecological risk assessment is beyond the scope of the present document and is presented in a number of available resource documents from CCME. "A Framework for Ecological Risk Assessment" general guidance and technical appendices would be the best reference. These may be obtained from CCME.

2.3 Step 3 - Corrective Action Plan

The Corrective Action Plan should describe how the decommissioning is to take place. The plan should detail procedures for handling emergencies which could occur during the decommissioning process, tank and associated equipment removal, treatment/disposal of hazardous substances, waste dangerous goods, contaminated materials and field and verification sampling.


Step 1: Preliminary Review and Completion of a Site Investigation.
Step 2: Determine which remediation criteria to use. Tier 1 Tier 2 or Tier 3
Step 3: Completion of a Corrective Action Plan or Risk Management Plan
Step 4: Submit an Application for the Decommissioning of Petroleum Storage Facilities with the Corrective Action Plan.

All pertinent information must be submitted to the department when the Corrective Action Plan is complete. The plan should include a schedule of when the work is to be carried out, name(s) of qualified persons and companies performing work, fate of tanks and associated piping, fate of any contaminated soil and the ultimate land use of the property. The plan should note that soil and groundwater sample analysis results will be required to evaluate if petroleum contamination has

been remediated properly. The plan will be reviewed by the department to determine its acceptability, and in some cases in consultation with the owner, and local officials. If the plan is acceptable, the department will approve the proposal in writing and the project can begin. If not acceptable, the department will identify deficiencies and ask that the plan be upgraded.

Corrective Action Plan submissions prepared by the proponent should be submitted in two report volumes: the first volume as a project summary report, and the second volume containing the detailed Corrective Action Plan proposal. The format for each are below:

Volume One – The Project Summary Report should contain the following material:
1. A cover sheet stating the project name, the name of the proponent, and the name of principal investigators
2. A project summary providing background information.
3. Site Investigation Report
4. Site Sensitivity Report (only in certain cases such as Tier 2)
5. Site-Specific Risk Assessment (only in certain cases such as Tier 3)

Volume Two – The Detailed Corrective Action Plan Proposal should contain the following:
1. A cover sheet stating the project name, the name of the proponent, and the name of principal investigators.
2. Proposal summary stating the corrective action plan objectives and a brief description of the nature of the proposed corrective actions.
3. A description of the proposed corrective plan including appropriate details regarding each plan component:
Contaminant treatment approach;
Implementation strategy;
Operation and monitoring;
Contaminant disposal and treatment;
Reclamation feasibility and impacts; and
Post-project site conditions and any applicable land use restrictions.
4.A description of proposed management plan detailing the schedule, duration of each treatment activity, project monitoring (sampling and analysis program), progress reporting, and long-term management and monitoring requirements.
5. A description of proposed verification testing including final clearance sampling and verification analysis program.
6.Identification of any adverse environmental impacts that cannot be fully mitigated by proposed corrective plan. Analysis of these impacts in terms of alternative treatment strategies.

If the proponent has decided to remediate using the Tier 3 approach a development of Site-specific Risk Assessment Plan and Long Term Monitoring Plan is required. Restrictions and management conditions would be required to ensure that the physical, land use and receptor characteristics do not vary from those assumed in the risk assessment. Where long term remediation techniques are

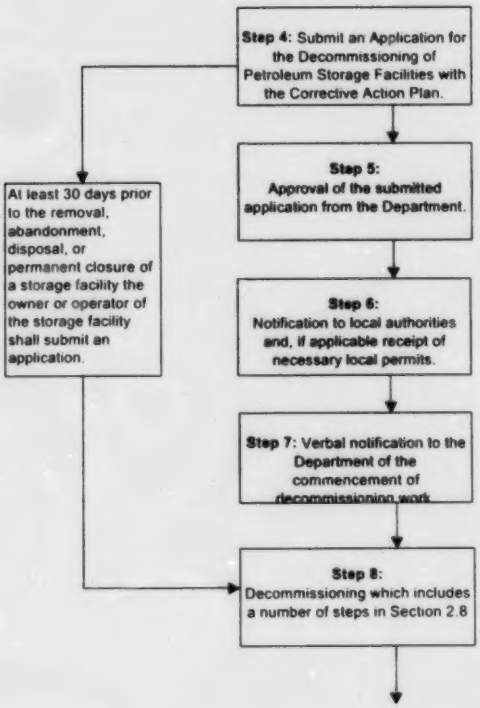
used, ongoing monitoring would be required to assess the progress of the remediation and to ensure that adverse impacts do not arise from the existing contamination present prior to completion of remediation. Under certain circumstances it may be possible, and advantageous, to implement risk management measures, without associated remediation, aimed at providing long term protection of receptors and elimination of exposure pathways. Examples of such situations include operating facilities where natural attenuation is being relied upon in the long term or sites where remediation can only practically be accomplished at the time of site closure or redevelopment. In these cases, monitoring would be required to ensure that conditions do not become worse with time, and that the risk management measures are effective.

In the above cases, particularly those in which active remediation is not contemplated, the non-toxicity-based considerations outlined in Section 1.1 must be observed and addressed (i.e. explosion hazard, aesthetic considerations and avoidance of free product).

2.4 Step 4 - Submission of An Application

Notification of decommissioning is to be achieved through the completion and submission of an Application for Approval to Decommission a Petroleum Storage Facility, 30 days prior to the decommissioning. In the case of a remediation based on future land use, completion of this application 30 days in advance will also provide most of the information the department requires in order to review and, provided the information is complete and satisfactory, grant approval for the project. If the proponent intends to employ either the remediation based on site-specific sensitivity or remediation based on risk assessment and management approach, then a detailed proposal (Corrective Action Plan), as required by subsections 17(2) and 17(3), should also be submitted. Further information as well as applications may be obtained by contacting this department's EcoRegional Offices. These offices are shown on Figure 2.4. Applications are supplied in Appendix 'C'. Office location and applications may also be obtained from this department's website www.serm.gov.sk.ca.

Figure 2.4: Location of EcoRegions and Offices


Step 4: Submit an Application for the Decommissioning of Petroleum Storage Facilities with the Corrective Action Plan.
Step 5: Approval of the submitted application from the Department.
Step 6: Notification to local authorities and, if applicable receipt of necessary local permits.
Step 7: Verbal notification to the Department of the commencement of decommissioning work
Step 8: Decommissioning which includes a number of steps in Section 2.8
At least 30 days prior to the removal, abandonment, disposal, or permanent closure of a storage facility the owner or operator of the storage facility shall submit an application.

2.5 Step 5 - Approval of the submitted application from the Department

The department reviews the Corrective Action Plan and application. If acceptable the department will grant approval in writing. If the plan is not acceptable the department will request additional information or refuse the application.

2.6 Step 6 - Notification of Local Authorities

Some municipalities have established bylaws with specific requirements for removal and decommissioning of storage tanks to reduce fire risks and protect publicly owned utilities and infrastructures. Anyone planning decommissioning, site assessment or risk management activities is advised to contact the municipal authorities, such as municipal engineering or fire departments, for specific local requirements.

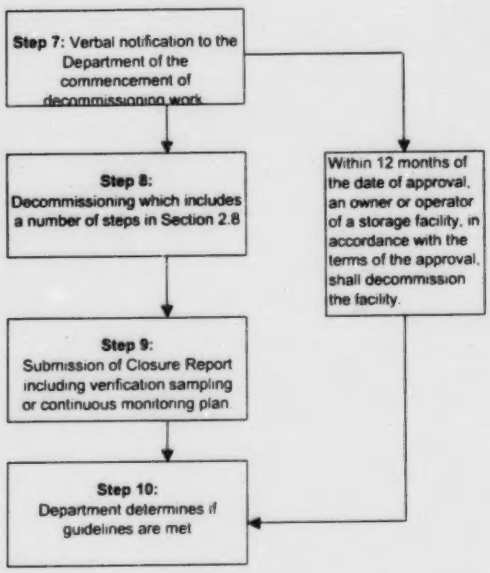
2.7 Step 7 - Verbal Notification to the Department

Verbal notification is required to the Department before the commencement of any decommissioning.

2.8 Step 8 - Decommissioning

Generally, the decommissioning will involve the removal of tanks and any equipment (the

source of the contamination) and remediation of soil and water contamination if present. Tank and associated equipment removal should be carried out in accordance with API Bulletin 1604 – Recommended Practice for the Abandonment or Removal of Used Underground Service Station Tanks (aboveground tanks should follow similar procedures). Soil and water contamination should be remediated using appropriate technology.


Step 7: Verbal notification to the Department of the commencement of decommissioning work
Step 8: Decommissioning which includes a number of steps in Section 2.8
Within 12 months of the date of approval, an owner or operator of a storage facility, in accordance with the terms of the approval, shall decommission the facility.
Step 9: Submission of Closure Report including verification sampling or continuous monitoring plan
Step 10: Department determines if guidelines are met

Remediation work should be performed or supervised by a qualified person. Employing local contractors for non-critical steps such as removal and spreading of soil is acceptable and will likely reduce costs. However, the HSWDG regulations require that a "qualified person" should guide the actual removal of the tanks and determine the extent of cleanup and collection of samples to verify completion of the decommissioning. Below are the typical steps followed to decommission a petroleum contaminated site.

2.8.1 Emergency Contingency Plan

Prior to starting any work, a safety plan or emergency contingency plan should be included in the Corrective Action Plan. The emergency contingency plan should describe what measures will be taken in emergency situations (e.g. what to do, and who to contact if explosive vapours are identified or when other potentially dangerous situations arise).

2.8.2 Cleaning, Purging and Removal

The tank removal process begins with exposing the top of the tank and the draining and flushing of the lines back into the tank. Next the fill and drop tube should be removed. At this point, the tank should be emptied using a vacuum truck or other means to ensure that as much liquids as possible are removed. The tank must then be cleaned and finally purged (removal of flammable vapours), inerted (removal of oxygen), and all tank openings must be plugged and capped. Purging may be performed after the tank has been removed from the excavation. If this is the case, the tank openings (including corrosion holes) should be plugged or capped before removing the tank.

The purging operation may release explosive vapours into the surrounding area, therefore, it will be necessary to ensure that safety precautions are taken. An explosive gas meter should be used to monitor the area and a safety plan must be in place. Inerting is achieved by replacing the oxygen within the tank by some other material. The most common method involves using dry ice (carbon dioxide). Approximately 1.5 kg of dry ice is required for every 1,000 litre tank capacity (or 1.5 lbs/100 gal capacity).

2.8.3 Disposal of Contaminated Liquids

Any liquids removed from the tanks, including wash water, are considered Waste Dangerous Goods and must be handled according to The Saskatchewan Dangerous Goods Transportation Act and Regulations. A generator number must be acquired from the department and the waste petroleum product must be manifested and disposed/treated of in an environmentally sound manner. For information regarding generator numbers, contact the department at (306) 787-6180.

2.8.4 Storage and Disposal of Tanks

It should be recognized that even after the tanks have been purged or inerted, explosive gases can be regenerated from residual product still present in the tank. Tanks should be stored in

an area not accessible to the public. A tank should be stored at least 30 metres from adjoining property lines and separated by a distance of at least one metre from each other. Tanks should be vented to prevent excessive build up of pressure within the tank. Orientation of tank vents downward will allow quick dispersion of heavier than air flammable vapours and will also prevent the accumulation of precipitation inside the tank.

The Hazardous Substances and Waste Dangerous Goods Regulations require that underground tanks be rendered unfit for further use for the storage of hazardous substances or waste dangerous goods. This can be accomplished by puncturing them in several places or by cutting holes in the ends when tanks are gas free. Ultimately, the tanks should be cut up and used as scrap metal.

2.8.5 Mitigation of Petroleum Contamination

There are many methods for handling petroleum contamination at a facility. Contaminated soil can be excavated and treated at an approved site/facility through land spreading, low temperature thermal desorption (a mechanical system that introduces heat to the soil causing volatile components to evaporate) or by incineration of the soil. Excavation and land spreading at an approved site is the most commonly used treatment method.

Treatment of soil without excavation (in-situ treatment) can also be used, however these technologies are only practical in certain situations. It should be noted that these systems can be expensive and if not applied properly can aggravate the problem. In-situ methods include but are not limited to Vapour Extraction Systems, Bioremediation, On-Site Aeration, and Liquid Recovery/Groundwater Treatment. If any of the in situ methods are to be used, ultimately the risk management criteria will have to be met or exceeded and plans should be submitted to the department describing how the technologies will be applied.

These options should be explored with the goal of identifying the most cost effective management option that will ensure that an acceptable amount of risk remains after the project is completed. These technologies are described below:

Excavation and Disposal
Measurements of combustible vapour concentrations as well as the concentrations of Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), Fractions F1 to F4, and lead in soil and groundwater are required to establish compliance with the prescribed cleanup criteria. Optional field screening techniques such as the measurement of combustible vapour concentrations during excavation may be used to facilitate the determination of excavation extent and disposal destination, and as a basis for selecting samples for more detailed testing. However, the limitation of such measurements with respect to quantification of the parameters of interest must be recognized.

In-Situ Vapour Extraction
In-situ vapour extraction is in most cases a long-term risk management technique. As with all treatment techniques methods, confirmation that the soils meet the prescribed criteria requires measurement of the concentrations of BTEX, Fractions F1 to F4, and lead in representative samples of soil and, where appropriate, groundwater. This will normally be performed following project completion. However, due to the long-term nature of the cleanup process, monitoring and analysis should be performed on an ongoing basis to assess the progress. Although no criteria presently exist for contaminant concentrations in soil vapours, laboratory analysis of vapour samples is strongly recommended as a means of assessing directly the health risks associated with the contamination remaining at any stage during or following the project.

In-Situ Bioremediation
In-situ bioremediation, like in-situ vapour extraction, is a relatively long-term process and thus requires a certain amount of ongoing monitoring as well as post remedial verification testing. Analysis of soil and groundwater samples to determine concentrations of BTEX, Fractions F1 to F4, and lead will be required to verify completion of the cleanup to the prescribed criteria. In addition, sampling and analysis of the groundwater at intervals during the project will be required, and ongoing monitoring of piezometers to determine groundwater table elevations and subsurface vapour concentration during the project is strongly recommended.

In-Situ Aeration
On-site aeration is a means of soil treatment to permit reuse or disposal of the soil. Obviously, the soil must be tested during and/or following the project to ensure that it meets the prescribed risk management criteria or disposal site acceptance requirements. This would normally involve sampling and analyzing the soil to determine concentrations of BTEX, Fractions F1 to F4, and lead. Monitoring of soil vapour concentrations during the aeration process may be used to assess the progress of the project. The previously contaminated area(s) of the site, from which the soil undergoing aeration was removed, will be subject to the same verification requirements as outlined above for sites utilizing soil excavation and disposal.

Liquid Recovery/Groundwater Treatment
Liquid recovery and groundwater treatment are addressed in these guidelines only in so far as they form part of a UST site risk management scheme as opposed to treatment or rehabilitation of an aquifer. The requirements for monitoring and testing are based on the need to ensure that the quality of groundwater returned to the subsurface or otherwise disposed of is within applicable guidelines and that the effects of the operations on the groundwater regime are acceptable and controlled. Sampling and analysis of groundwater, both from the subsurface and from the treatment system discharge, will be required periodically to determine concentrations of BTEX and lead. Piezometric levels throughout the area affected by the withdrawal of fluids should be monitored on an ongoing basis. The requirements that pertain to other means of risk management also apply in this case with respect to ensuring that overall site risk management criteria are met. The extent of verification testing required in each case will be dictated by a number of factors including: the degree to which the extent of contamination was defined in the initial investigation, the risk management approach adopted and the amount and type of testing conducted during the project.

2.8.6 Soil Excavation

Once the excavation is opened up, measures will have to be taken to ensure that contaminated soils are identified, removed and dealt with in the proper manner. Petroleum contamination can usually be initially identified by discolouration or odour. Removal of soil to achieve the Tier 1 or Tier 2 criteria of these guidelines is then required. This may not be required for the Tier 3 level. If there is any indication of leakage such as liquid product or visible holes in the tank or lines, Saskatchewan Environment are to be notified as soon as practical by calling the **Spill Report Center toll-free 24 hours a day at 1-800-667-7525.**

For gasoline and similar contaminants, a combustible gas indicator calibrated to a hexane standard should be used to obtain "head space" measurements of hydrocarbon vapours in the soil. These measurements will be used as a guide for how close to completion the project is. Excavation should proceed to a level that will ensure that contamination has been removed to levels indicated in the Tier 1 or Tier 2 Criteria for Soil and that no explosion hazard exists. For monitoring of remediation progress during excavation, a drive rod can be used to create a hole about 15-30 cm into soil where the analyzer probe can be inserted for peak readings to be recorded.

When excavation is thought to be at or near completion, combustible gas readings should be taken from samples when soil is at room temperature. This can be achieved by taking soil cuttings (any lumps should be gently broken by hand) and placing then in a one litre sealed plastic bag filled approximately 3/4 full. The sample should then be allowed come to room temperature. A reading should not be taken until the sample has reached a temperature of a least 15°C. Once this temperature is reached, the probe should be used to puncture the bag in the headspace above the soil. The sample should then be gently agitated and the peak reading during the first 15 seconds should be recorded. This procedure should ensure consistency of readings between samples. It has been found that a combustible gas level of 10 per cent Lower Explosive Limit (LEL) is generally a good indicator that excavation is nearing completion for situations where gasoline spills have occurred. The age of spilled gasoline may affect the validity of this indicator, since in coarse soils, light ends of gasoline may be attenuated by evaporation and therefore give potential

false readings. At this point, confirmation of completion to the criteria found in Table 2.2.1 and 2.2.2 should be considered by collection and submission of soil samples.

For soils contaminated with diesel, heating oils or weathered gasoline, removal must continue until the target values provided in Table 2.2.1 and 2.2.2 have been achieved. Adverse aesthetic contamination indicated by odour or visual discoloration are good initial indicators of remaining significant contamination. The value of combustible gas meter readings for indication of reduced concentrations is lessened for diesel fuel, heating oils and similar products, because these products have a higher flashpoint and are less volatile than gasoline.

2.8.7 Soil Treatment

If the chosen treatment method is soil venting (land spreading and tilling), the Guidelines for Treatment and Disposal of Petroleum Contaminated Soils at Municipal Waste Grounds should be followed. These guidelines are available from the department as a separate document. Contaminated soils may have to be monitored and sampled to ensure that they have been treated properly. The department must give prior approval for final disposal of treated soils if they are not to be used for cover at the municipal waste disposal grounds.

Several other options for treatment of petroleum contaminated soil also exist including bioremediation, thermal desorption, incineration and other on site techniques. Please contact the department for specific information regarding these alternative soil treatment methods.

2.8.8 Water Treatment

In instances where petroleum contamination is suspected or known and where it may pose a threat to groundwater, a monitoring program should be established in consultation with qualified professionals. As well, if the protection of potable groundwater and the protection of groundwater for aquatic life pathways cannot be eliminated then contaminated groundwater must be remediated to criteria presented in Table 2.8.1. Piezometers must be installed for the purpose of defining and monitoring groundwater conditions. Generally, piezometers should be completed with the screened

interval across the zone of contamination. If a water level exists, an adequate number of piezometers should be installed to establish both direction or flow and gradient. Groundwater samples should be analyzed for BTEX and Lead.

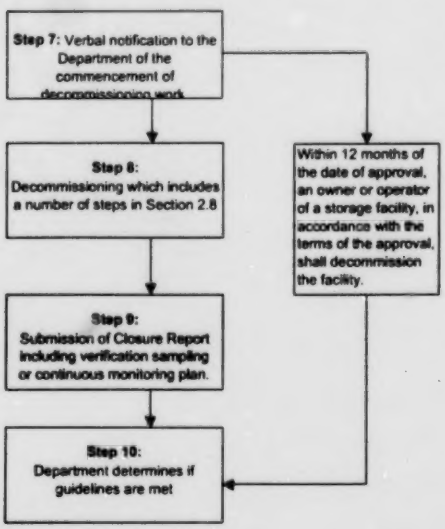
Table 2.8.1: Summary of Risk Management Criteria for Groundwater Based On Groundwater Use (ug/l or parts per billion)

Parameter	Freshwater/ Aquatic	Irrigation	Livestock	Potable Groundwater
Benzene	370	—	—	5
Toluene	2	—	24	24
Ethyl benzene	90	—	2.4	2.4
Xylenes	—	—	—	300
Lead	1 to 7	200	100	10

Derived from the Canadian Environmental Quality Guidelines (1999)

It is recommended that up and down-gradient samples be taken. Sampling should be repeated in order to improve confidence in the results. A review of the sampling results will be necessary to determine if further measures are required to control contamination of groundwater. Any cleanup action must be documented and supplied to the department in a monitoring report.

2.9 Step 9 - Verification Sampling and Closure Report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Step 9: Submission of Closure Report including verification sampling or continuous monitoring plan.
Step 10: Department determines if guidelines are met

In order to complete a decommissioning, a sampling program will have to be carried out to verify that the risk remaining after completion of the decommissioning is acceptable. Soil samples should include samples from the tank bed, excavation walls and from the pump island area. The number of samples required will vary for each situation. In

general, the more samples taken, the more likely conditions at the site are characterized accurately, and the more likely the site will present an acceptable amount of risk. The number of samples required by the department is dependent on the number of tanks that existed. Generally there should be at least one more sample than the number of tanks that existed. Samples should be taken from excavated areas below obviously contaminated areas (e.g. areas where high combustible vapour readings were taken, below tanks or below the pump island) and on the sidewalls of the excavation. The following procedure can be used to take samples. Completely fill each sample jar so that no headspace exists, wipe soil from the jar threads, and seal the jar using a Teflon or aluminum lined cap. Label the jar and place it in a covered cooler with ice for transport to a laboratory for analysis for components indicated in Tiers 1 or 2.

In order for the department to evaluate if criteria have been met, a final or closure report must be submitted using either a Decommissioning Closure Report Form, available from the department and included in Appendix 'C', or the equivalent. Should the latter reporting option be selected, the submission must include the work schedule, names of companies who performed work including the name of the certified contractor, the fate of any equipment removed from ground (tanks, pipes, etc.), description of treatment method, fate of contamination, future land use, verification sampling results and any ongoing monitoring (on and off site). The following format can be used:

1.0 Summary Cover Sheet
Including owner, operator, facility name, facility address, facility registration number (if applicable), contractor company name, qualified person's name and certification number.

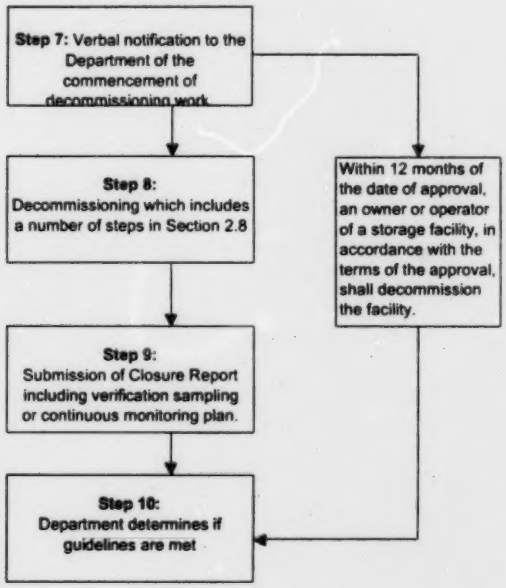
2.0 General Facility and Site Information
Facility and site history.
Anticipated future land use.

3.0 Summary of Corrective Action
Description of how and when site was remediated.
Number of tanks or piping systems present and how may were found to be leaking upon removal.
Fate of tanks and associated equipment.
Treatment/ disposal of contaminated materials.
Volume of contaminated soil removed.
Sampling schedule for land spread contaminated soil, where applicable.
Off site contamination action plan, where applicable.

4.0 Verification Sampling
Name of laboratory performing analysis.
Description of sampling methods.
Physical location of samples (diagram).
Summary of results.
Copy of laboratory analytical results.

5.0 Comments
Recommendations or general comments about special circumstances regarding the project.

2.10 Step 10 - Department Approval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Step 10: Department determines if guidelines are met

The Closure Report should be submitted to the department as soon as feasible after completion. The department will comment on whether these guidelines have been met. A final declaration as to the complete cleanup of the site will not be issued, as these guidelines are based on risk management techniques. The department will however, comment on whether an acceptable amount of risk remains, subject to the accuracy of the information supplied.

Appendix 'A'

Appendix A - Site Investigation

1.0 General

This section summarizes the site and subsurface information required in the site investigation and remediation process. The primary purpose of the site investigation is to determine the nature and extent of contamination. The information collected in the investigation will provide the basis for evaluating potential impacts on land use and the environment. The information will also be used to formulate a remediation plan. Site information, investigation and testing requirements are summarized in Table A1. The requirements are discussed in the following paragraphs.

Phase 1 property assessment is a preliminary, qualitative investigation conducted to reveal any potentially significant environmental concerns. A "Phase 1" assessment includes a historical review of operations and land use, site inspection and interviews with persons knowledgeable of the operations at a site. "Phase 1" reveals only indications of potential contamination of soils or groundwater and whether additional investigation is warranted. If a future land use based remediation approach is going to be used and the storage facility is relatively small with a limited or well defined operational history, a "Phase 1" site investigation may provide all of the information necessary for a Tier 1 type decommissioning to begin. However, in most cases at petroleum contaminated sites a Phase 2 investigation is required.

Phase 2 is a detailed site investigation that will confirm, quantify and determine the extent of environmental contamination as indicated by the "Phase 1" investigation. "Phase 2" will involve determining soil stratigraphy and hydrogeology (soil texture, layers and groundwater flow), sample and data collection, sample analysis and interpretation of this and other pertinent information, to provide detailed knowledge about the environmental conditions at a site. If Tier 2 remediation based on site specific sensitivity is selected, this information may be gathered as the contaminated soils are uncovered and dealt with.

Phase 3 is a more detailed evaluation of site conditions to more completely characterize the contamination and select optimum remedial options and may be particularly important in large scale decommissioning projects. Based on information gathered from Phase 1 and 2 investigations, remedial options are explored with the aim of developing a Tier 3 risk based corrective action plan in a " Phase 3 " investigation.

Further detail and the requirements for performing Tier 1, 2, and 3 remediation are provided in Table - A1 and discussed in detail below.

2.0 Land use and sensitivity factors

The following can be obtained through a site inspection and a review of available technical information:

Site description and land use

- Type of municipality (city, town, village etc.)
- Land use within 150 meters of site (type, distance and direction)
- Proposed use of site.

Table A1: Summary Of Site Information and Subsurface Investigation

Requirements	Tier 1	Tier 2	Tier 3
Land use and sensitivity factors			
Site Description	X	X	X
Land use	X	X	X
Proximity to surface and drinking water	X	X	X
Human and ecological receptors	X	X	X
Site dimensions and distances to receptors	R	X	X
Physical conditions			
Soil Texture	X	X	X
Soil stratigraphy and physical properties	X	X	X
Hydrogeological conditions	X	X	X
Additional soil properties	O	X	X
Additional hydrogeological conditions	O	X	X
Contamination - Nature & Extent			
Characteristics	X	X	X
Distribution/Deliniation	X	X	X
Contaminant composition and distribution		X	X
Secondary user-adjustable parameters		X	X
Tier 3 Investigations			
Degree and extent of PHC contamination			X
Characteristics of site soil and groundwater			X
Building characteristics			X
Receptor specific toxicity information			X

Notes:

X = Required **R** = Recommended **0** = Optional (dependant of specific conditions)

Proximity to surface and drinking water

- Distance and direction of all wells within 300 meters and their ownership and use (private, municipal, domestic, irrigation etc.)
- Depth to usable aquifer.
- Evidence of groundwater discharge to surface water bodies.
- Major subsurface drainage direction (if known)
- Any surface water bodies within 10 to 300 meters.
- Type of surface water (lake, creek, dugout etc.)
- Local surface drainage direction
- Downstream users.

Human and ecological receptors

- Presence of basements or similar underground structures within 100 meters
- Distance to nearest underground structure in each direction.

- Presence of buried utilities, vaults etc. on or adjacent to site.
- Presence of rare and/or endangered species, ecological reserves and sensitive habitats

3.0 Physical conditions

One of the objectives of the site investigation is to determine whether the site broadly fits any of the four generic land use categories. Below are some of the physical conditions which are required.

Soil Texture

- Sufficient textural information should be obtained to permit classification of the soils as either coarse or fine for the Tier 1 level. Additional information such as soil texture, organic carbon fraction, soil porosity, bulk density, and soil moisture content is required at the Tier 2 and 3 levels.

Soil Stratigraphy and Physical Properties

- Soil stratigraphy and physical properties may be obtained by the review of geological maps, reports and well records.
- Nature, lateral extent and continuity of surficial deposits.
- Depth to, and nature of, bedrock.

Hydrogeological Conditions

- Common information required at the Tier 1 level includes depth to groundwater and flow direction, hydraulic gradient and possibly hydraulic conductivity. This information may be reported qualitatively. However, similar information at Tier 2 and 3 levels would require a site specific groundwater investigation quantifying this information. In addition, this investigation would require the establishment of a hydrological recharge rate.

4.0 Contamination - Nature and Extent

Sufficient characterization of PHC contamination should be conducted for the purpose of comparing contaminant concentrations with Tier 1 values.

Characteristics

- This will comprise of the collection and laboratory analysis of representative soil samples to determine concentrations of the four PHC fractions and BTEX.

Distribution and Delineation

- In most cases the specialist will conduct sufficient sampling to delineate the lateral and vertical extent of impacted soils. If these extents fall within 30 cm to the foundation of an occupied building or 10 m of the high water mark of a surface water body and the concentrations exceed the remediation criteria for the specific land use then Tier 1 does not apply.

Contaminant composition and Distribution

- Sufficient additional PHC characterization data will be required to support any adjustments at the Tier 2 level. The primary adjustable parameters are source dimensions and depth to upper and lower limits of impacted soil and composition relative to weathered mixtures.

Secondary user-adjustable parameters

- As well, there are a number of secondary-user adjustable parameters which are outlined in the Canada-wide Standard.

5.0 Tier 3 Investigations

The information required for implementation of Tier 3 must include sufficient site and PHC characterization, data pertinent to fate and transport modeling, receptor characteristics, toxicity information and other information needed to permit the site-specific quantification of risk and establishment of remediation objectives. Remediation based on natural attenuation, biodegradation, source depletion and other transformations requires sufficient evidence of these processes occurring given the site conditions.

6.0 Site Investigation Methodology

6.1 Introduction

The purpose of this section is to provide a summary description of an acceptable approach and methodology for subsurface tank leak/spill investigations. The methodology presented in the following subsections is intended mainly for the benefit of underground storage tank (UST) owners, operators and managers charged with ensuring execution of a proper site investigation. Adherence to the recommended methodology will permit adoption of a unified investigative approach for most underground tank site assessments conducted in Saskatchewan. Although one set of standard investigation methods cannot be developed to fully apply to every situation on site, the approach and methods presented are generally acceptable for most site conditions. However, as numerous substances are stored in underground storage tanks in addition to hydrocarbons fuels, major portions of the recommended approach and methodology may not be suitable for sites potentially affected by contaminants other than hydrocarbon fuel. The scope of this section and of the methodology presented is therefore limited to petroleum products. In all situations, experienced contamination investigation professionals should be consulted and their judgment relied upon to design the most effective investigation program for any given site or contaminant. It is also recommended that the site investigation be conducted by an experienced team that is well qualified in the appropriate engineering and science disciplines. It is necessary to rely on this professional investigation team for the evaluation of information needs, the integration of all site specific information into an effective investigation/sampling plan, collection of representative samples and interpretation of the resulting data. Ultimately the team is responsible for the provision of an investigation which is responsive to both the regulatory and environmental objectives outlined in this guidance document.

6.2 Investigation/sampling plan

The initial and perhaps most critical element of an underground storage tank site investigation is the investigation/sampling plan. The purpose of the plan is to ensure the collection of all data required to define the extent and degree of subsurface contamination. Site specific knowledge is required to design and execute an effective plan. An on-site investigation is necessary to become familiar with the site and provide information required for plan development and implementation. Site specific factors include:

- Site history and adjacent land use;

- Site infrastructures;
- Location of underground tanks and associated facilities;
- Past and present contents of tanks;
- Source, type, and estimated volume of released contaminants;
- Surficial geology, hydrology, and hydrogeology;
- Preferential migration pathways and proximity of receptors;
- Underground utilities and services; and
- Potential hazards and accessibility.

Preliminary hydrocarbon vapour surveys may also assist the planning of more detailed investigations at some sites. This preliminary survey generally involves the mapping of subsurface vapour concentrations based on a grid of shallow probe holes.

An investigation/sampling plan must describe the individual tasks and sampling effort, as well as when and how they will be performed. For proper interpretation and evaluation of collected data, the data must be generated by a scientifically effective sampling program. Key components of the plan should include:

- Field equipment requirements;
- Borehole location patterns for on-site and off-site investigations;
- Groundwater monitoring well location, design, and construction;
- Sample preservation and analytical considerations;
- Soil sampling strategy and equipment;
- Groundwater monitoring and sampling strategy;
- Quality assurance and quality control program; and
- Personnel and public health and safety requirements.

Site specific knowledge of contaminant pathways and the influence of geologic, hydrologic, chemical and other forces in the subsurface, is often far from complete prior to initiation of field investigations. Subsurface assessments therefore require a phased approach, regardless of the initially perceived size or scope of investigation.

The investigation/sampling plan should be comprehensive as it, together with the skill, training, and experience of the field investigators, will largely determine the investigation program's success. Because the sample handling and analytical requirements are also essential components of the plan's development.

The approach and methodology for field and laboratory investigation components of the plan, are discussed in the following sub-sections.

6.3 Investigative Program

6.3.1 Quality Assurance and Quality Control

Quality Assurance (QA) is a systematic process for ensuring that all collected data and the decisions based on these data are technically sound, statistically valid and properly documented. The program involves a series of steps, procedures and practices required to ensure a specified degree of confidence.

Quality Control (QC) procedures are the methods employed to measure the degree to which

the quality assurance objectives are met.

General QA and QC measures which should be employed for subsurface site assessments include:

a) Use of proven and appropriate investigation methods, such as those recommended in this section, by trained field and laboratory personnel;

b) Inspection of all field equipment, sampling apparatus and instruments to ensure they are clean, calibrated, and in good working condition;

c) Documentation of all field and laboratory activities so that sample results may be evaluated correctly with respect to site conditions, sample collection and handling methods, and sample analyses;

d) Use of field quality control measures which requires field blanks and duplicate sample analyses to detect contamination during handling and transport, and document analysis precision; and

e) Coordination with the laboratory for the preparation of sampling containers, and for preservation, packaging, shipping and receipt of samples to ensure meaningful data through timely analyses of valid samples.

In addition to the above general requirements, laboratory QA/QC protocols must be employed in the analytical portion of the assessment program.

6.3.2 Field Investigations

The evaluation and initial selection of the number, locations, spacing and monitoring frequency of subsoil boreholes and groundwater wells needed to define and/or monitor any contamination requires the knowledge and understanding of specific site characteristics. Below is a general approach to the investigation. Additional information on field investigations may be obtained from ASTM's "ASTM Standards on Ground Water and Vadose Zone Investigations: Drilling, Sampling, Geophysical Logging, Well Installation and Decommissioning, 2nd Edition."

The nature of the contamination if known, the potential sources of contamination and the location of potential migration pathways are considered in relation to the local geology and hydrogeology. Actual final field placement will most often depend not only on pre-targeted locations and depths but on the progressive field evaluation of additional needs as indicated by the surface and subsurface conditions encountered during drilling. Field methods that follow include:

- Borehole investigation and soil sampling techniques;
- Field hydrocarbon vapour measurements;
- Groundwater observation well installation and design; and
- Groundwater monitoring and sampling.

6.3.2.1 Investigations

Investigative boreholes are normally augured using a mobile drilling rig equipped with the necessary drilling and sampling devices to define subsurface conditions. A split spoon sampler is generally the preferred soil sampling device.

Subsoil samples should be collected at 0.75 meter intervals and at every stratigraphic change. Sampling depths are entirely site specific and will normally depend upon field observations. Subsoil stratigraphy at each borehole location should be logged and subsoil units classified according to the Unified Soil Classification System. Any visual anomalies and evidence of contamination should also be recorded. A typical borehole log is presented in Figure A1.

Soil Samples

The splitspoon soil sample should be trimmed with ~ 20 mm at each end discarded to minimize cross contamination of samples. A representative portion of the sample is then divided longitudinally; one half (laboratory sample) is transferred with minimum headspace to a 500 ml laboratory sample container, second half (field sample) is reserved for field vapour screening. Laboratory sample containers should be glass and must have tight fitting lids, be labeled, and stored on site in ice filled coolers. Screw-type lids with foil or Teflon cap liners are preferred. Laboratory samples should be transported, at the completion of daily field investigations, along with chain of custody documentation, to the analyzing laboratory.

Sampling tools and equipment should be properly cleaned between successive samples to prevent cross-contamination. Generally detergent and water solutions are effective cleaning agents when followed by distilled water rinses. In some cases (i.e. oily contaminants) additional cleaning with organic solvents (i.e. acetone, methanol) may be required.

Field Hydrocarbon Vapour Screening

To guide the drilling operation and provide a preliminary evaluation of subsoil contamination, the reserved field sample is analysed for volatile vapours using a hydrocarbon vapour analyser. Field vapour levels should always be measured on the reserved field sub-sample which is then discarded. They should not be measured on the sub-sample which is to be returned to the laboratory for analysis.

Field readings should be taken when the sample is at a temperature of approximately 15^{0}C. Once this temperature is reached, the probe should be used to puncture the one litre plastic bag filled approximately 3/4 full, in the headspace above the soil. The sample should then be gently agitated and the peak reading during the 15 seconds should be recorded. This procedure should ensure consistency of readings between samples. Upon completion, all boreholes drilled for descriptive logging and subsoil sampling purposes only, should be sealed with bentonite clay to minimize potential pathways for contaminant migration. Drill cuttings should not be used as backfill as they may not provide an adequate seal and may contribute to cross-contamination.

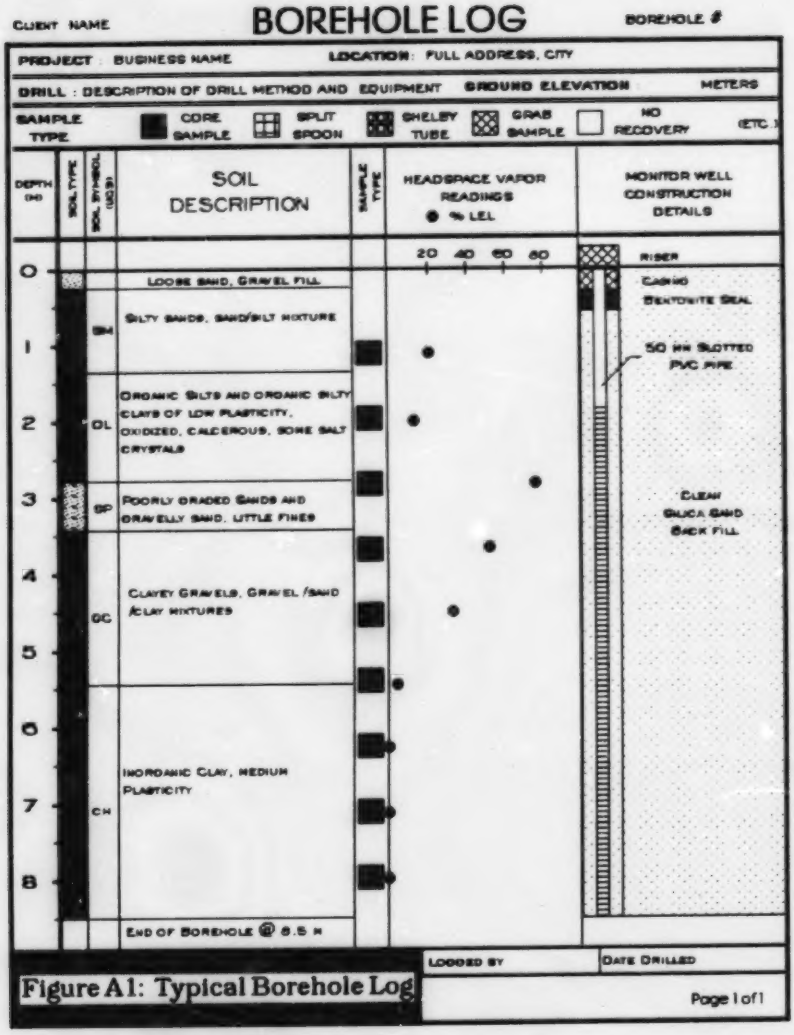

Figure A1: Typical Borehole Log

6.3.2.2. Groundwater evaluation

Observation Well Location

Observation wells are constructed as standpipe piezometers and should be placed in locations surrounding the suspected sources of groundwater contamination. Although most wells will be constructed down gradient from the suspected source, up gradient and lateral locations are required for both background assessment and evaluation of geologically complex settings.

Some or all of the observation wells may be installed in subsoil sampling boreholes. However, it should be recognized that these may not always be appropriate locations for well placements.

Design and Installation of Observation Wells

Groundwater observation wells should be constructed with flush-joint, threaded pipe casings which have a minimum inside diameter of 50 mm. These are installed in a boring whose diameter is at least 100 mm greater than the diameter of the casing. PVC or Stainless steel casing and screen material is recommended.

Observation wells should be constructed as filter-packed wells wrapped with filter fabric so that particles of natural soil cannot enter. A uniform sandpack is recommended. The well screen should be factory perforated with a slot size adequate to prevent entry of filter material. Filter packs should extend approximately 0.5 m above the perforated screen interval to allow for compaction of the filter material. All stand pipes shall have a bottom cap or plug drilled with a relief hole to prevent false readings and to prevent formation materials from entering the well during installation.

Proper well construction is essential to ensure the observation well itself does not become a route for contaminant migration. Wells should be constructed where possible to provide depth discrete measurements for individual flow zones. Slotted screen intervals must be located to coincide with the groundwater surface in order to measure the accumulated thickness of any phase-separated hydrocarbon product (free product).

Installation of a continuously slotted screen that cuts across and links several flow zones should be avoided to minimize the risk of cross zone contamination. This is of particular concern in subsoil units where free product is evident, and in areas where the location of the stabilized groundwater surface is unknown or where large seasonal fluctuations may occur. In these areas, a nest of several piezometers (installed in separate adjacent boreholes) with slotted screen intervals at varying depths is recommended to enable independent observation of several horizons or flow zones.

Groundwater observation wells should be sealed from the top of the filter pack to the ground surface. The backfill material installed above the filter pack should be a low permeability material with known chemical properties (i.e. bentonite). The use of drill cuttings as backfill will not ensure an adequate seal. The uppermost meter of the well annulus should be backfilled with a concrete grout. The grout should extend above the ground surface and be finished to slope away from the well axis. This concrete plug and apron will inhibit downhole infiltration of surface water. Well heads should be fitted with a water tight cap and enclosed in a structure that secures the well against accidental damage, unauthorized access, and

vandalism. The recommended design for the construction of standpipe piezometers is presented in Figure A2.

Subsoil stratigraphy and lithology (soil types and thickness of layers) should be logged and subsoil units classified according to the Unified Soil Classification system prior to the well construction. A sketch of each well constructed should be prepared to accompany visual observations and apparent groundwater elevations recorded on the borehole/well log. All wells should be surveyed relative to a suitable bench mark for the measurement and evaluation of groundwater elevations.

Groundwater Monitoring and Sampling

All observation wells should be monitored for water levels and the presence of any phase-separated or free hydrocarbon product floating on the water surface. If liquid product is present its thickness should first be measured using an interface probe. Whenever possible, the free product should be removed, its volume recorded and additional monitoring conducted to determine recovery rates. Samples of free product should be collected for laboratory characterization of the contaminant.

It is essential that water levels stabilize prior to use of the elevation data to assess groundwater flow. Monitoring of water levels and free product thicknesses should be conducted at least twice and on separate site visits. The actual number of monitoring wells depend on well stabilization rates.

Prior to sampling groundwater for dissolved constituent analyses, the well must be purged to remove stagnant water retained in the standpipe water volume or to dryness. The groundwater sample may then be collected using a bailer or other suitable device and transferred to 1,000 ml laboratory sample containers. Duplicate samples are recommended. The containers should be glass and must have tight screw-type lids with foil or Teflon cap liners. Collected samples, once transferred, should have no visible headspace or evidence of any free product. Samples should be stored in ice filled coolers while on site, and transported as soon as practical after sampling to the analyzing laboratory, along with chain of custody documentation.

Dedicated sampling devices should be used for each well installation, or equipment must be thoroughly cleaned between each successive well sampling.

6.3.3 Laboratory Investigations

The number of soil and groundwater samples submitted for laboratory examination must be sufficient to quantify the total extent (both vertical and lateral) and degree of subsurface soil and groundwater contamination.

Analysis parameters will include, but not be limited to:

- Benzene, Toluene, Ethyl benzene and Xylene;
- PHC fractions 1 to 4;
- Lead.

Recommended laboratory method for the analyses of soil samples is CCME's "Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons in Soil - Tier 1 Method."

Initial analytical work-up for contaminant identification should include qualitative analysis of selected samples. These may be samples with elevated field vapour levels and/or free product from observation wells to characterize or confirm the hydrocarbon contaminant. Quantitative methods should then be chosen which are appropriate for the identified contaminants.

Laboratories that perform analysis of collected samples should evaluate their QA/QC programs against the required analytical procedures. QC procedures should include the analysis of duplicate spike samples, blanks (field and reagent), check samples and surrogate standard recoveries. Appropriate QA and QC measures should be used to ensure all data generated is suitable for the objectives of this investigation.

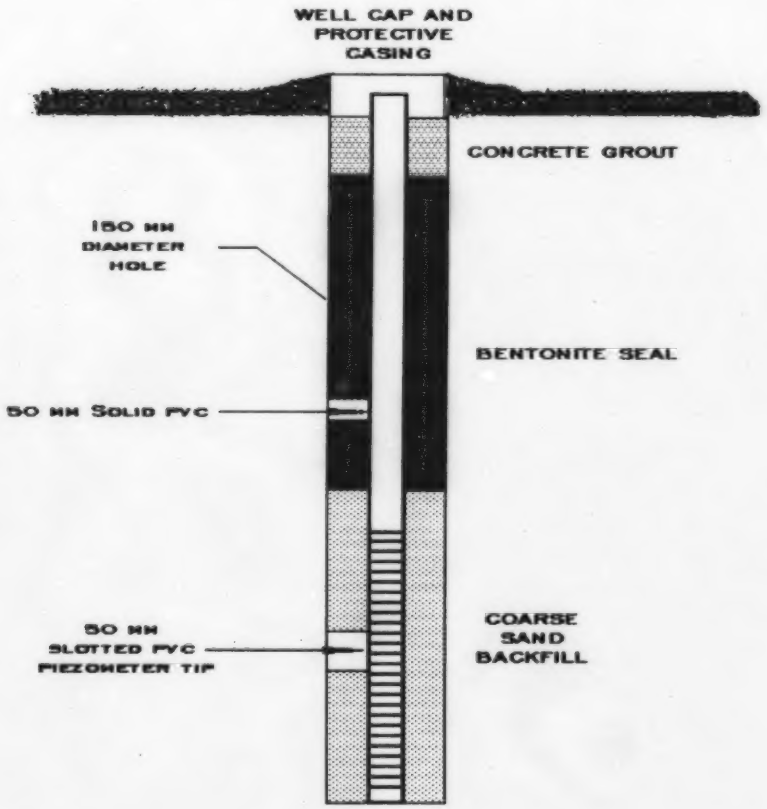

Figure A2: Typical Standpipe Piezometer Detail

7.0 Report Submissions

Reporting should include:

A) Introduction
- Proponent's name and address;
- Investigator's name and address; and
- Legal description or municipal address of the site

B) Background
- Site occupants and nature of the business, relevant site history, and identified contaminant releases.

C) Site Description
- Description of the site and surrounding land uses;
- On-Site and adjoining infrastructures;
- Applicable site and surrounding land use maps showing site location, infrastructures, and underground tank facilities; and
- Photographs

D) Field Investigations
- Investigation/sampling plan and QA/QC summary;
- Detailed procedures used for subsoil and groundwater evaluations;
- Borehole and observation well location plan at an appropriate scale;
- Borehole log and observation well construction drawings and details;
- Field hydrocarbon vapour measurements; and
- Groundwater monitoring data and free product measurements

E) Laboratory Investigations
- Identified contaminant(s)
- Analysis rationale (i.e. number of samples and parameter);
- Soil and groundwater analysis results with supporting documentation

F) Data Evaluation
- Subsurface contamination encountered;
- Field hydrocarbon vapour measurements and laboratory sample analysis correlations;
- Groundwater/free product evaluations; and
- Laboratory analyses interpretation;

G) Site Assessment
- Extent and degree of identified subsurface contamination;
- Contaminant concentrations in context of cited Criteria; and
- Environmental conditions and public health and safety concerns.

H) Conclusions and Recommendations
- Immediate response requirements;
- Site sensitivity assessment requirements;
- Remediation options available, action level required; and
- Additional investigations required.
- Laboratory QA/QC procedures and QC sample results.

Appendix 'B'

TABLE B1
LAND-USES, KEY RECEPTORS AND EXPOSURE PATHWAYS

Exposure Pathway	Agriculture	Residential/ Parkland	Commercial	Industrial
Soil Contact	Nutrient cycling Soil invertebrates Crops (plants) Livestock/wildlife Human (toddler)*	Nutrient cycling Invertebrates Plants Wildlife	Nutrient cycling Invertebrates Plants Wildlife	Nutrient cycling Invertebrates Plants
Soil and Food Ingestion	Herbivores Human (toddler)	(wildlife)**	(wildlife)	(wildlife)
Soil Particulate Inhalation	Human (toddler)	Human (toddler)	Human (toddler)	Human (adult)
Groundwater/ Surface Water	Aquatic Life/ Livestock Watering Human (toddler)	Aquatic Life Human (toddler)	Aquatic Life Human (toddler)	Aquatic Life Human (adult)
Indoor Vapour Intrusion	Human (toddler)	Human (toddler)	Human (toddler)	Human (adult)
Produce, meat and milk produced on site	Human (toddler)	Human (toddler) • Produce only		
Off-site migration of Soil/Dust				Human/Eco

* Health Canada defines a toddler as a child of age 7 months to 4 years. This age group generally receives the greatest dose per unit body weight and, therefore, represents a critical receptor for human health risk assessment and guidelines development for land uses they may frequent.

** wildlife dermal contact and ingestion data may be particularly important for PHCs (e.g., oiling of feathers, etc., although this should be addressed with an initial assessment of the presence of non-aqueous phase liquids - NAPL), but there are unlikely to be sufficient data to develop guidelines that address this exposure pathway

TABLE B2
TIER 1 LEVELS (mg/kg soil) FOR PHCs FOR COARSE-GRAINED SURFACE SOILS

Land Use	Exposure Pathways	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	15000	8000	18000	25000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor 30 m offset)	200	1100	RES	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Protection of GW for Livestock Watering[2]	9000	4000	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	130	450	400	2800
	Eco Soil Ingestion	TBD	TBD	TBD	TBD
	Produce, Meat and Milk	NC	NC	NC	NC
Residential	Soil Ingestion	15000	8000	18000	25000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, basement)	50	240	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	30	150	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	130	450	400	2800
	Produce	NC	NC	NC	NC
Commercial	Soil Ingestion	RES	29000	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	310	1700	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NC	NC
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	330	760	1700	3300
Industrial	Soil Ingestion	RES	RES	NA	NA
	Dermal Contact	RES	RES	RES	NA
	Vapour Inhalation (indoor)	310	1700	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NC	NC
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	330	760	1700	3300
	Offsite Migration	NA	NA	RES	RES

NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded.
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined
1 = Assumes surface water body at 10 m from site.
2 = Includes use of dugouts and wells for supply of livestock water.
3 = Tier 1 values based mainly on laboratory bioassay response to fractions derived from fresh Federated Crude Oil.

TABLE B3

TIER 1 LEVELS (mg/kg soil) FOR PHCs FOR FINE-GRAINED SURFACE SOILS

Land Use	Exposure Pathways	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	15000	8000	18000	25000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (Indoor 30 m offset)	2100	11400	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Protection of GW for Livestock Watering[3]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	260	900	800	5600
	Eco Soil Ingestion	TBD	TBD	TBD	TBD
	Produce, Meat and Milk	NC	NC	NC	NC
Residential	Soil Ingestion	15000	8000	18000	25000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	940	5200	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	260	900	800	5600
	Produce	NC	NC	NC	NC
Commercial	Soil Ingestion	RES	29000	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	4600	25000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	660	1500	2500	6600
Industrial	Soil Ingestion	RES	RES	NA	NA
	Dermal Contact	RES	RES	RES	NA
	Vapour Inhalation (Indoor)	4600	25000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	660	1500	2500	6600
	Offsite Migration	NA	NA	12000	RES

NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined
1 = Assumes site is underlain by groundwater of potable quality in sufficient yield (K of 10^{-4} cm/sec or greater).
2 = Assumes surface water body at 10 m from site.
3 = Generally applicable for this land use as related to use of dugouts and wells for supply of livestock water.
4 = Tier 1 values based primarily on laboratory bioassay response to fractions derived from fresh Federated Crude Oil and adjusted for textural factors.

TABLE B4
GENERIC LEVELS FOR PHC IN COARSE-GRAINED SUBSOIL (> 1.5 m depth)

Land Use	Exposure Pathways	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor 30 m offset)	200	1100	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Protection of GW for Livestock Watering[2]	9000	4000	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[3]	350	1500	2500	10,000
	Eco Soil Ingestion	NA	NA	NA	NA
	Produce, Meat and Milk	NA	NA	NA	NA
Residential	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor, basement)	50	240	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	40	190	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[3]	350	1500	2500	10,000
	Produce	NC	NC	NC	NC
Commercial	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor)	340	1800	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[3]	700	2000	3500	10,000
Industrial	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor)	340	1800	NA	NA
	Protection of Potable GW[1]	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[3]	700	2000	3500	10,000
	Offsite Migration	NA	NA	NA	NA

NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded.
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined
1 = Assumes surface water body at 10 m from site.
2 = Includes use of dugouts and wells for supply of livestock water.
3 = Tier 1 values based primarily on laboratory bioassay response to fractions derived from fresh Federated Crude Oil and adjusted for depth factors and other physical hazard considerations.

TABLE B5
GENERIC LEVELS FOR PHCS IN FINE-GRAINED SUBSOIL (> 1.5 m depth)

Land Use	Exposure Pathways	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor 30 m offset)	2100	11,400	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Protection of GW for Livestock Watering[3]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	750	2200	3500	10,000
	Eco Soil Ingestion	TBD	TBD	TBD	TBD
	Produce, Meat and Milk	NA	NA	NA	NA
Residential	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor)	990	5500	RES	NA
	Protection of Potable GW[1]	940	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	750	2200	3500	10,000
	Produce	NA	NA	NA	NA
Commercial	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor)	4800	26000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	1000	3000	5000	10,000
Industrial	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (Indoor)	4800	26000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	1000	3000	5000	10,000
	Offsite Migration	NA	NA	NA	NA

NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded.
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined
1 = Assumes site is underlain by groundwater of potable quality in sufficient yield (K of 10^{-4} cm/sec or greater).
2 = Assumes surface water body at 10 m from site.
3 = Generally applicable for this land use as related to use of dugouts and wells for supply of livestock water.
4 = Tier 1 values based primarily on laboratory bioassay response to fractions derived from fresh Federated Crude Oil and adjusted for texture, depth factors and other physical hazard considerations.

Appendix 'C'

Saskatchewan Environment

Application For Decommissioning Petroleum Storage Facilities Based On Future Land Use

Date of Application _____ Facility Code _____

Section 1 – Storage Facility Information

Is facility registered with Saskatchewan Environment? ☐ Yes ☐ No

Business Name: _____

Address of Storage Facility: _____
(street address)

_____ City, Town, Village _____ Province _____ Postal Code _____ Telephone

Owner Name: _____
(business name or individual)

Owner Address: _____
(mailing address)

_____ City, Town, Village _____ Province _____ Postal Code _____ Telephone

Aboveground Tank Information

Tank #	Capacity	Content	Age

Underground Tank Information

Tank #	Capacity	Content	Age

Section 2 – Qualified Personnel

Pursuant to the *Hazardous Substances and Waste Dangerous Goods Regulations*, decommissioning of petroleum storage facilities must be performed by qualified personnel. The company performing corrective actions is to complete the following section:

Company Performing Decommissioning: _____ _____ Telephone

Address: _____
(mailing address)

_____ City, Town, Village _____ Province _____ Postal Code

Qualified Personnel: _____ Certification Number: _____ (if applicable) _____ Signature

Form continued on next page.

Section 3 – Corrective Actions

Project Start Date: _____ Estimated Time to Complete Project: _____

Has a Site Investigation or Environmental Audit been performed at this property? ☐ Yes ☐ No
(if Yes, include a copy with this application, unless previously submitted to department.)

What is the anticipated future land use? ☐ Agricultural ☐ Residential/Parkland ☐ Commercial/Industrial

How will tanks be disposed of? _____

_____

_____

How will contaminated site be treated?

☐ Landspread and tilled at landfill (Attach letter granting permission from owner of landfill)

☐ Other _____ (Specify – supply detailed written report describing method of treatment.)

Section 4 – Landspread Soil Monitoring

Who will be responsible for tilling and monitoring soil?

☐ Facility Owner ☐ Landfill Owner ☐ Contractor ☐ Other (specify) _____

Contact Name: _____ _____
Telephone

Section 5 – Facility Diagram

A detailed site diagram including the following information must be supplied with application:

- Utilities (above and below ground)
- Tank locations
- Pump island locations
- Product delivery lines
- Vent lines
- Roadways
- Buildings
- Distance to water wells
- Distance to surface water
- Depth to groundwater
- Distance to nearest residence

Note: Information supplied through this application will be used by department officials to determine the acceptability of the proposed decommissioning. When corrective actions are complete, a closure report is required to be filed with the department. The closure report will detail the corrective actions taken pursuant to this application.

For Office Use Only – Do Not Write in This Space

Project Number: _____ Approval Date: _____

Project Officer: _____ EcoRegion: _____

Saskatchewan Environment

Decommissioning Closure Report Form

Section 1 – Storage Facility Information

Facility Code _____ Project Number _____ Date _____

Business Name: _____

Address of Storage Facility: _____
(street address)

_____ _____ _____ _____
City, Town, Village Province Postal Code Telephone

Company Performing Decommissioning: _____ _____
(company name) Telephone

Qualified Personnel: _____ Certification Number: _____

Section 2 – Underground Storage Site Information

Was the area of the pump island checked for contamination? ☐ Yes ☐ No

Was the island removed during the decommissioning? ☐ Yes ☐ No

Was the area of the product delivery lines checked for contamination? ☐ Yes ☐ No

Was there any impact on utility lines by contamination? ☐ Yes ☐ No

Was there any impact on the foundation of any remaining buildings by contamination? ☐ Yes ☐ No

Was there any off site migration of the contaminant discovered during excavation? ☐ Yes ☐ No

Section 3 – Aboveground Storage Site Information

Was the area of the loading rack checked for contamination? ☐ Yes ☐ No

Were there any underground lines associated with this site? ☐ Yes ☐ No

Was the area of the product delivery lines checked for contamination? ☐ Yes ☐ No

Was there any impact on utility lines by contamination? ☐ Yes ☐ No

Was there any impact on the foundation of any remaining buildings by contamination? ☐ Yes ☐ No

Was there any off site migration of the contaminant discovered during excavation? ☐ Yes ☐ No

Section 4 – General Decommissioning Information

Amount of soil removed _____ m^3

Please note that if at any time during the excavation utility corridors are found to be in the path of the contaminant plume or if the contaminant migrates off the facility site, Saskatchewan Environment and local authorities must be notified immediately. If free phase product is encountered during the excavation or on top of the water table, the department and local authorities must be notified immediately.

Section 5 – Site Diagram

Please supply a diagram of this site after the excavation. Please indicate the approximate dimensions of the excavation, including the depth of the excavation at the tank farm, the product delivery lines and the pump island. Show distances from the excavation to the buildings and road ways. Indicate the areas of contamination. Please indicate where explosive vapour readings were taken, and assign each location a unique identification number on the diagram. In tabular form please indicate the % LEL readings and the depth at which the reading was taken. Please indicate where the soil samples were taken. A minimum of three soil samples will be required. The larger the excavation, the greater the number of samples required. If the water table is high enough to impact the excavation at least one water sample should be taken.

Section 6 – Analytical Results

If a letter stating that the facility is decommissioned is required from the department, at least 3 soil samples (and if ground water implications are a concern at least 1 water sample) are to be submitted to an accredited lab to be analyzed for petroleum hydrocarbons and their constituents. A copy of these results must be forwarded to the department.

I, THE UNDERSIGNED CERTIFY THAT ALL THE SAMPLES SUBMITTED FOR ANALYSIS WERE FROM THE EXCAVATION OF THIS PROJECT AND ARE REPRESENTATIVE OF CONDITIONS FOUND IN THE EXCAVATION, AND THAT APPROVED SAMPLING TECHNIQUES WERE EMPLOYED AT ALL TIMES DURING THE SAMPLING.

_____ _____

Name of Person Collecting the Samples Signature

Number of Samples Taken? ____ ____ _____

Soil Water Name of Lab

FOR OFFICE USE ONLY. PLEASE DO NOT WRITE IN THIS SPACE

_____ _____ _____

Environment Officer's Name Signature Date

Were analytical results included? ☐ Yes ☐ No Were results satisfactory? ☐ Yes ☐ No

Level of clean-up achieved? _____ Is any further follow up required? ☐ Yes ☐ No

If Yes, nature of follow up? _____